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IGLOO WAVE ABSORBER TESTS FOR PORT WASHINGTON HARBOR, WISCONSIN

Hydraulic Model Investigation

by

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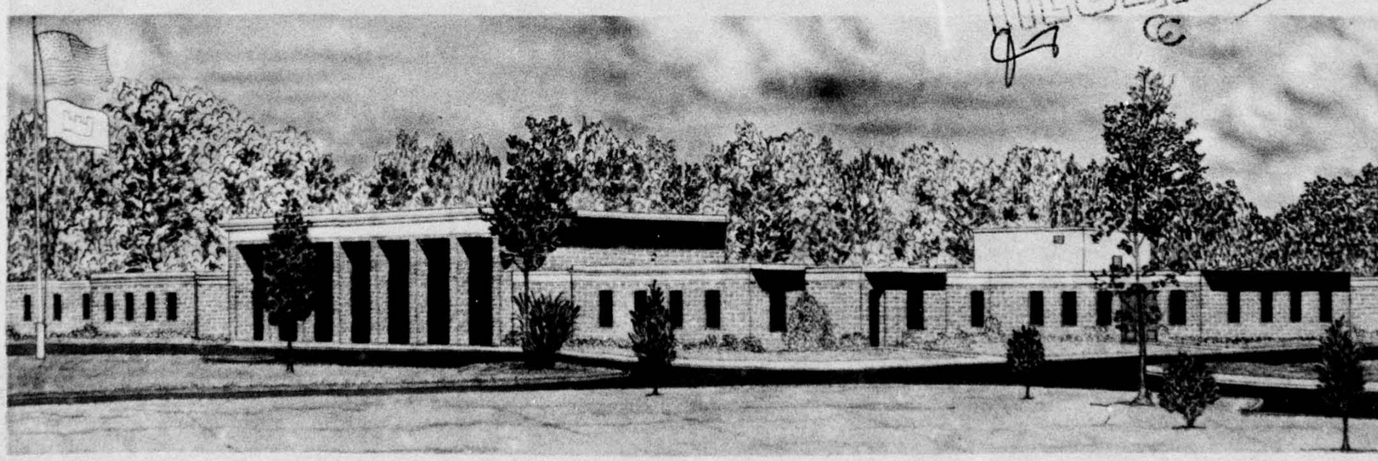
P. O. Box 631, Vicksburg, Miss. 39180

November 1976
Final Report



Prepared for Nippon Tetrapod Co., Ltd.
Shimbashi, Japan

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Igloo wave absorbers	Water wave absorbers

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Port Washington Harbor is exposed to waves generated by storms from northeast to south-southeast. Storm waves from these directions have caused damage to harbor facilities and boats and difficulties to ships and craft navigating the harbor entrance. Standing waves in the slip areas have reached heights of 12 ft. Anchorage in the outer harbor is not safe for small boats due to lack of adequate wave protection. Hence, the harbor is unsafe as a harbor-of-refuge. Consequently, there is no harbor-of-refuge between Milwaukee and Sheboygan,

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20. ABSTRACT (Continued)

a distance of 56 miles. Also, Port Washington Harbor does not have adequately protected permanent mooring and docking facilities to accommodate the demand for such facilities in this area.

Hydraulic model tests were conducted to determine the effects of installation of Igloo wave absorber units in the harbor. Conclusions drawn from the results of these tests were that (a) Igloo wave absorber units placed in and around the slip areas will significantly reduce wave heights in the slips; (b) east and west breakwaters constructed of Igloo units without backing will not be stable; (c) a 500-ft-long Igloo structure adjacent to the north breakwater as an alternative to the east breakwater will not meet established wave-height criteria; and (d) a 200-ft-long Igloo east breakwater (with backing) will meet the established wave-height criteria.

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PREFACE

The investigation reported herein was authorized on 28 Sep 1976 by Agreement No. WES-76-17 with Mr. Robert Q. Palmer, representing Nippon Tetrapod Co., Ltd.

This study was conducted at the U. S. Army Engineer Waterways Experiment Station (WES) during October 1976 in the Wave Dynamics Division (WDD), Hydraulics Laboratory (HL), under the direction of Mr. H. B. Simmons, Chief of the HL, and Dr. R. W. Whalin, Chief of the WDD. The tests were conducted by Mr. R. R. Bottin, Jr., Project Engineer, with the assistance of Messrs. C. W. Coe, and R. E. Ankeny under the supervision of Mr. C. E. Chatham, Jr., Chief of the Harbor Wave Action Branch. This report was prepared by Mr. Bottin.

Mr. Robert Q. Palmer, Consultant for Nippon Tetrapod Co., Ltd, visited WES to observe model operation and participate in a conference.

COL J. L. Cannon, CE, was Director of WES during the conduct of this investigation and preparation of this report. Mr. F. R. Brown was Technical Director.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
acres	4047.0	square metres
square feet	0.092903	square metres
square miles	2.58999	square kilometres

IGLOO WAVE ABSORBER TESTS FOR

PORT WASHINGTON HARBOR, WISCONSIN

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. Port Washington, Wisconsin, is located on the west shore of Lake Michigan about 29 miles* north of Milwaukee, Wisconsin, and 27 miles south of Sheboygan, Wisconsin. The city, which had a population of 8700 in 1970,[1] is a trading center and the seat of Ozaukee County. The downtown portions of the business and manufacturing sections have been developed around the harbor.

2. Port Washington Harbor is entirely artificial and is located at the outlet of a small stream known as Sauk Creek. The harbor area comprises approximately 60 acres and is enclosed by a 3500-ft-long breakwater system. The outer harbor is maintained at a project depth of 21 ft and the inner harbor, or slip area, is maintained at a project depth of 18 ft.

The Problem

3. Port Washington Harbor is exposed to waves generated by storms from northeast clockwise to south-southeast. Waves caused by storms from these directions have caused considerable damage to harbor facilities and recreational boats, and difficulties to ships and recreational craft navigating the harbor entrance. Standing waves set up in the slip areas of the harbor (due to reflections off the vertical steel sheet-pile bulkheads) have resulted in wave heights up to 12 ft. Anchorage in the outer harbor is not safe for small boats due to the

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

lack of adequate wave protection. These conditions make the harbor unsafe as a harbor-of-refuge for small boats resulting in no adequate small-boat refuge between Milwaukee and Sheboygan, a distance of 56 miles. In addition, there is a lack of adequately protected permanent mooring and dock facilities to accommodate the great demand for such facilities in the Port Washington area.

Corps Sponsored Investigation and Conclusions

4. The Port Washington model was initially constructed and tested for the U. S. Army Engineer District, Chicago (NCC). The investigation included a small-boat harbor within the existing deep-draft harbor. Proposed improvements consisted of (a) new east and west breakwaters with lengths of 320 ft and 1010 ft, respectively, arranged to form a protected harbor of approximately 13.5 acres; (b) a 10-ft deep, 150-ft wide entrance channel; (c) a 10-ft deep anchorage-maneuvering area, approximately 3.5 acres in extent; (d) an 8-ft deep, 72-ft wide launching ramp channel extending from the anchorage-maneuvering area to a launching ramp; (e) a 500-ft rubble-mound wave absorber, adjacent to the existing north breakwater extending northwesterly from the new east breakwater at its junction with the north breakwater; and (f) safety railings on the new east and west breakwaters. NCC specified that, for an improvement plan to be acceptable, wave heights should not exceed 2.0 ft in the anchorage-maneuvering area and 1.0 ft in the mooring area for incident wave conditions occurring during the boating season (spring and summer).

5. Based on the results of the Corps sponsored model investigation, the following conclusions were made:

- a. Existing conditions are characterized by very rough and turbulent waves in the vicinity of the proposed harbor during periods of severe wave attack.
- b. The proposed improvement plan (plan 1) was considered inadequate, in that the established wave-height criteria were exceeded for waves from all directions due to overtopping of the existing north breakwater and overtopping of and transmission through the proposed east and west breakwaters.

c. Of the improvement plans tested involving modifications to the existing north breakwater (adjacent to the proposed harbor), the concrete parapet wall (+12 ft-lwd) in conjunction with wave absorbers inside the breakwater (+4 ft-lwd elevation and 6-ft berm width) was determined to be optimal, considering wave protection afforded and cost.

d. To achieve the established wave-height criteria in the proposed small-boat harbor, it was determined that the crown elevations of the east and west breakwaters must be raised and/or an impervious center must be added.

e. The zigzag west breakwater alignment (plan 7A) resulted in smaller waves at the coal wharf (S37°10'E direction) than the straight west breakwater alignments (plans 6 and 8); however, maximum wave heights obtained at the coal wharf for plans 6 and 8 were comparable to maximum wave heights obtained for existing conditions, considering all directions tested.

f. Removal of 185 ft from the shore end of the west breakwater (plan 8) will improve wave-induced circulation without increasing wave heights in the proposed small-boat harbor.

g. Construction of the proposed small-boat harbor will have no adverse effects on the existing inner slips of the harbor.

h. Filling in approximately one-third of the existing north slip (as requested by the city of Port Washington-plan 9) will result in increased wave heights in the north slip.

Purposes of Igloo Absorber Tests

6. The purposes of model tests of the Igloo wave absorber units were to:

a. Determine if the installation of Igloos in the inner slip areas of the existing harbor would significantly reduce wave heights.

b Determine whether Igloo absorber units could be substituted for the rubble-mound breakwaters in the proposed small-boat harbor.

c. Determine if Igloos installed adjacent to the existing north breakwater could be used as an alternative to the proposed east breakwater and/or the wave absorber proposed for the small-boat harbor.

PART II: THE MODEL AND TEST CONDITIONS

Design of Model

7. The Port Washington Harbor model (Figure 1) was constructed to a linear scale of 1:75, model to prototype. Scale selection was based on (a) the depth of water required in the model to prevent excessive bottom friction; (b) the absolute size of model waves; (c) available shelter dimensions and the area required for constructing the model; (d) efficiency of model operation; (e) capabilities of available wave-generating and wave-measuring equipment; and (f) cost of model construction. A geometrically undistorted model was necessary to ensure accurate reproduction of short period wave patterns. Following selection of the linear scale, the model was designed and operated in accordance with Froude's model law.[2] The scale relations used for design and operation of the model were as follows:

Characteristic	Dimension*	Model:Prototype Scale Relation
Length	L	$L_r = 1:75$
Area	L^2	$A_r = L_r^2 = 1:5,625$
Volume	L^3	$\forall = L_r^3 = 1:421,875$
Time	T	$T = L_r^{1/2} = 1:8.66$
Velocity	L/T	$V_r = L_r^{1/2} = 1:8.66$
Discharge	L^3/T	$Q_r = L_r^{5/2} = 1:48,715$

* Dimensions are in terms of length (L) and time (T).

The Model and Appurtenances

8. The model, which was molded in cement mortar, reproduced the existing Port Washington Harbor, approximately 2600 ft of the shoreline on each side of the harbor, and underwater contours in Lake

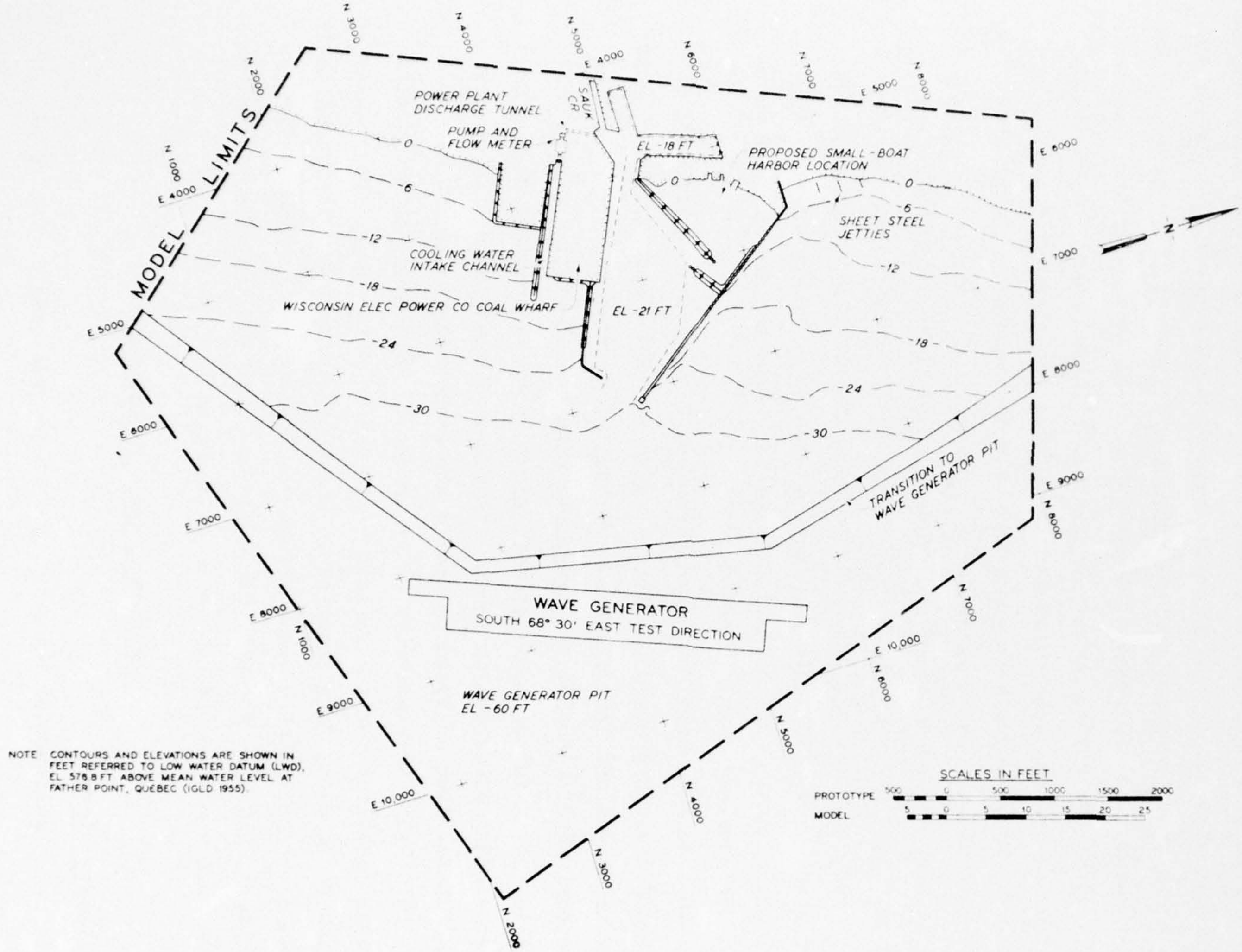

Figure 1. Port Washington model layout

Michigan to an offshore depth of -35 ft with a sloping transition to the wave generator pit elevation of -60 ft. The total area reproduced in the model was approximately 8660 sq ft, representing about 1.75 sq miles in the prototype. Vertical control for model construction was based on low water datum (lwd) the elevation* of which is 576.8 ft above mean water level at Father Point, Quebec (International Great Lakes Datum, 1955).[1] Horizontal control was referenced to a local prototype grid system.

9. Model waves were generated by a 50-ft-long wave generator with a trapezoidal-shaped, vertical-motion plunger. The vertical movement of the plunger caused a periodic displacement of water incident to this motion. The length of stroke and the period of vertical motion were variable over the range necessary to generate waves with the required characteristics. In addition, the wave generator was mounted on retractable casters, which enabled it to be positioned to generate waves from the required test directions.

10. An Automated Data Acquisiton and Control System (ADACS), designed and constructed at WES, was used to secure wave-height data at selected locations in the model. Basically, through the use of a minicomputer, ADACS recorded onto magnetic tape the electrical output of parallel-wire, resistance-type wave gages that measured the change in water surface elevation in respect to time. The magnetic tape output of ADACS was then analyzed to obtain the wave-height data.

11. Igloo wave absorber units (Photo 1) were used in the model at several locations for the various test plans. These units are stacked (Photo 2) so as to form chambers in which wave energy is dissipated as it moves both horizontally and vertically. Model Igloo casting units were furnished by Nippon Tetrapod Company, Ltd. WES fabricated molds and the actual Igloo units used in the investigation.

Selection of Test Conditions

Still-water level

12. A still-water level of +3.9 ft lwd was used during model

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* All elevations (el) cited herein are in feet referred to lwd.

testing. This value was obtained from lake stage frequency curves (furnished by NCC) for Milwaukee and Sturgeon Bay, Wisconsin, for a 10-year recurrence interval during boating season (May-October).

Selection of test waves

13. Wave characteristics for the Corps sponsored investigation were obtained from Reference 3 which covers deepwater waves approaching the harbor site from three angular sectors by season for recurrence intervals of 5, 10, 20, 50, and 100 years. Shallow-water wave heights and directions of wave approach were determined as a result of a wave refraction analysis conducted by WES. The following test waves were determined to be the most critical as a result of the Corps sponsored investigation and selected for the Igloo wave absorber tests.

Deepwater Direction	Shallow-Water Direction	Wave Period sec	Deepwater Wave Height, ft	Shallow-Water Wave Height, ft	Recurrence Interval yr
ESE	S68°30'E	5.5	4.0	3.8	0.33
		7.3	10.8	9.9	20.0
SSE	S37°10'E	8.3	12.1	10.4	20.0

Analysis of Model Data

14. Relative merits of the various plans were evaluated by a comparison of wave heights at selected locations in the harbor and visual observations. In analyzing the wave-height data, the average height of the highest one-third of the waves recorded at each gage location was selected. All wave heights thus selected were then adjusted to compensate for wave-height attenuation due to viscous bottom friction in the model by application of Keulegan's equation.[4] From this equation reduction of wave heights in the model can be calculated as a function of water depth, width of wave front, wave period, water viscosity, and distance of wave travel.

PART III: TESTS AND RESULTS

The Tests

Existing conditions

15. Wave-height data were obtained at various locations within the harbor (Plate 1) for the test directions listed in paragraph 13. Movie footage was secured in the slip areas for waves from S68°30'E.

Test plans

16. Wave-height tests were conducted for nine test plans which consisted of installation of Igloo absorber units at various locations in the slip areas and as alternatives to the originally proposed rubble mound breakwaters and absorber at the proposed small-boat harbor site. Movie footage, wave pattern photographs, and color slides were secured for some test plans. Brief descriptions of the test plans are presented in the following subparagraphs, dimensional details are presented in Plates 1-3.

a. Plan 1 (Plate 1) consisted of the installation of Igloo absorber units along the ends of the north and west slips.

b. Plan 1A (Plate 1) entailed the elements of plan 1 with Igloo units installed around the corners at the entrance of the west slip (75 ft from each corner).

c. Plan 1B (Plate 1) involved the elements of plan 1A with Igloo units installed along the landfill opposite the Wisconsin Electric Power Company coal wharf.

d. Plan 1C (Plate 1) consisted of the elements of plan 1B with Igloo units installed along 200 ft of the western end of the coal dock.

e. Plan 1D (Plate 1) entailed the elements of plan 1B with 100 ft of Igloo units installed perpendicular to the western end of the coal dock.

f. Plan 2 (Plate 2) involved the elements of plan 1B with an 825-ft-long, +8-ft-lwd Igloo west breakwater and a 320-ft-long, +12-ft-lwd Igloo east breakwater providing protection to the proposed small-boat basin.

g. Plan 3 (Plate 3) consisted of the elements of plan 2 except the west Igloo breakwater was replaced by an impervious rubble mound structure with a crown el of

of +8-ft-lwd. The east breakwater was removed, and 500 ft of the lakeward portion of the parapet wall and absorber were replaced with Igloo absorber units.

h. Plan 3A (Plate 3) entailed the elements of plan 3, but the lakeward head of the west breakwater was replaced with two rows of Igloo absorber units placed back to back.

i. Plan 3B (Plate 3) involved the elements of plan 3 with a 100-ft-long double row Igloo east breakwater installed at a 12 ft el.

j. Plan 3C (Plate 3) consisted of the elements of plan 3B with a 100-ft extension to the east breakwater.

k. Plan 3D (Plate 3) entailed the elements of plan 3C except the east breakwater consisted of one row of Igloo absorber units backed with a rubble absorber.

Wave-height tests

17. Wave-height tests for plans 1-1C were conducted using test waves from S68°30'E, and wave-height tests for plans 3-3D were conducted for test waves from S37°10'E. Wave gage locations for these test plans are shown in Plates 1 and 3.

Movie footage and wave pattern photographs

18. Movie footage was secured for plan 1B depicting wave conditions in the slip areas of the harbor for test waves from S68°30'E, while wave pattern photographs and color slides were obtained for plan 3C showing wave conditions in the proposed small-boat harbor for test waves from S37°10'E.

Test Results

19. In evaluating test results, the relative merits of each plan were based on an analysis of measured wave heights and visual observations. Model wave heights (significant wave height) were tabulated to show measured values at selected locations.

20. Results of wave-height tests for existing conditions and plans 1-1C are presented in Table 1. Maximum wave heights obtained for existing conditions and plans 1-1C were 14.6, 9.3, 5.9, 5.6, and 4.5 ft, respectively, in the west slip and 15.0, 11.0, 6.9, 5.1, and 4.8 ft, respectively, in the north slip.

Wave heights recorded at the center line of the west and north slips for existing conditions and plans 1-1C were plotted graphically as shown in Plate 4. Examination of these data reveals that each test plan (further addition of Igloo units) reduced wave heights in the slip areas. Considering wave protection afforded and the fact that it is not feasible to install Igloo units along the coal wharf, plan 1B was selected as the most promising plan and subjected to 5.5-sec, 3.8-ft test waves from S68°30'E (a condition which occurs much more frequently). A comparison of plan 1B wave heights with those for existing conditions for this test indicates a reduction from 5.9 to 1.4 ft in the west slip and 5.5 to 1.0 ft in the north slip. Curves depicting wave heights along the center lines of the west and north slips for existing conditions and plan 1B are shown in Plate 5. Plan 1D was installed during a conference while Mr. Robert Q. Palmer, Consultant for Nippon Tetrapod Co., Ltd, was observing model operation. Maximum wave heights obtained in the west and north slips were approximately 3.0 and 3.5 ft, respectively.

21. Visual observations secured with plan 2 installed in the model indicated that the east and west breakwaters were unstable and required some sort of backing. Due to economics, this was not considered feasible and no wave-height data were obtained for plan 2.

22. Results of wave-height tests with plans 3-3D installed in the model are presented in Table 2. Maximum wave heights obtained in the anchorage-maneuvering area (gages 18 and 19) were 2.8, 2.8, 2.0, 1.0, and 0.9 ft for plans 3-3D, respectively, while maximum wave heights obtained in the mooring area (gages 20 and 21) were 2.7, 2.8, 2.2, 0.8, and 0.8 ft, respectively. These data indicate that a 200-ft-long Igloo east breakwater with backing (plans 3C and 3D) is required to meet the wave height criteria established by NCC (a maximum of 2.0 ft in the anchorage-maneuvering area and 1.0 ft in the mooring area).

PART IV: CONCLUSIONS

23. Based on the results of the model investigation reported herein, it is concluded that:

- a. Igloo wave absorber units placed in and around the slip areas of the existing harbor significantly reduced wave heights in those slips.
- b. East and west breakwaters constructed of Igloo absorber units (plan 2) were not stable in that they required backing.
- c. A 500-ft Igloo absorber adjacent to the north breakwater (plan 3) used as an alternative to the east rubble mound breakwater did not meet the wave-height criteria established by NCC (a maximum of 2.0 ft in the anchorage-maneuvering area and 1.0 ft in the mooring area).
- d. A 200-ft-long Igloo east breakwater with backing (plans 3C and 3D) will meet the wave-height criteria established by NCC in the proposed small-boat harbor.

REFERENCES

1. U. S. Army Engineer District, Chicago, CE, "Detailed Project Report, Small-Boat Harbor Improvements at Port Washington Harbor, Wisconsin," August 1974, Chicago, Ill.

2. Stevens, J. C. et al., "Hydraulic Models", Manuals of Engineering Practice, No. 25, 1942, American Society of Civil Engineers, New York.

3. Resio, D. T. and Vincent, C. L., "Design Wave Information for the Great Lakes, Report 3, Lake Michigan," Technical Report H-76-1, Nov 1976, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

4. Keulegan, G. H., "The Gradual Damping of a Progressive Oscillatory Wave with Distance in a Prismatic Rectangular Channel," (Unpublished data), May 1950, U. S. Bureau of Standards, Washington, D. C.

Table 1

Wave Heights Obtained in Inner Slip Areas of Existing Harbor for Existing Conditions and Plans 1-1C

Test Direction	Test Wave Period sec	Test Wave Height ft	Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage 9	Gage 10	Gage 11	Gage 12	Gage 13	Gage 14	Gage 15
Existing Conditions																	
S68°30'E	5.5	3.8	4.7	1.9	4.5	3.2	5.9	4.7	1.9	1.5	2.1	5.5	1.9	1.5	2.1	4.1	2.9
	7.3	9.9	10.5	6.5	6.4	12.2	14.6	8.1	12.3	11.4	13.0	11.7	14.6	9.4	6.8	9.5	15.0
Plan 1																	
S68°30'E	7.3	9.9	5.1	7.1	6.0	5.3	5.4	9.3	6.1	6.7	8.7	5.7	9.2	9.1	4.1	9.2	11.0
Plan 1A																	
S68°30'E	7.3	9.9	5.6	4.8	3.5	3.8	3.4	5.9	3.8	3.7	3.2	3.2	5.5	4.4	2.6	4.8	6.9
Plan 1B																	
S68°30'E	5.5	3.8	1.4	0.7	1.3	1.1	0.8	0.8	0.7	0.5	0.7	1.0	0.6	0.5	0.6	0.7	0.6
	7.3	9.9	4.9	4.7	2.9	3.2	3.0	5.6	2.5	2.2	2.3	2.1	3.7	3.7	1.7	4.3	5.1
Plan 1C																	
S68°30'E	7.3	9.9	3.9	4.1	2.0	2.6	2.4	4.5	2.2	3.1	1.6	2.0	3.2	2.9	2.0	3.0	4.8

Table 2

Wave Heights Obtained in the Small-Boat Harbor for Plans 3-3D

Test Direction	Test Wave Period sec	Test Wave Height ft	Wave Height at Indicated Gage Location, ft Gage 16	Gage 17	Gage 18	Gage 19	Gage 20	Gage 21
			Plan 3					
S37°10'E	8.3	10.4	10.9	7.1	2.8	1.5	2.7	1.0
			Plan 3A					
S37°10'E	8.3	10.4	12.3	7.6	2.8	1.8	2.8	1.1
			Plan 3B					
S37°10'E	8.3	10.4	9.7	4.9	1.5	2.0	2.2	1.0
			Plan 3C					
S37°10'E	8.3	10.4	8.5	2.8	1.0	0.8	0.8	0.4
			Plan 3D					
S37°10'E	8.3	10.4	9.0	2.6	0.9	0.9	0.8	0.6

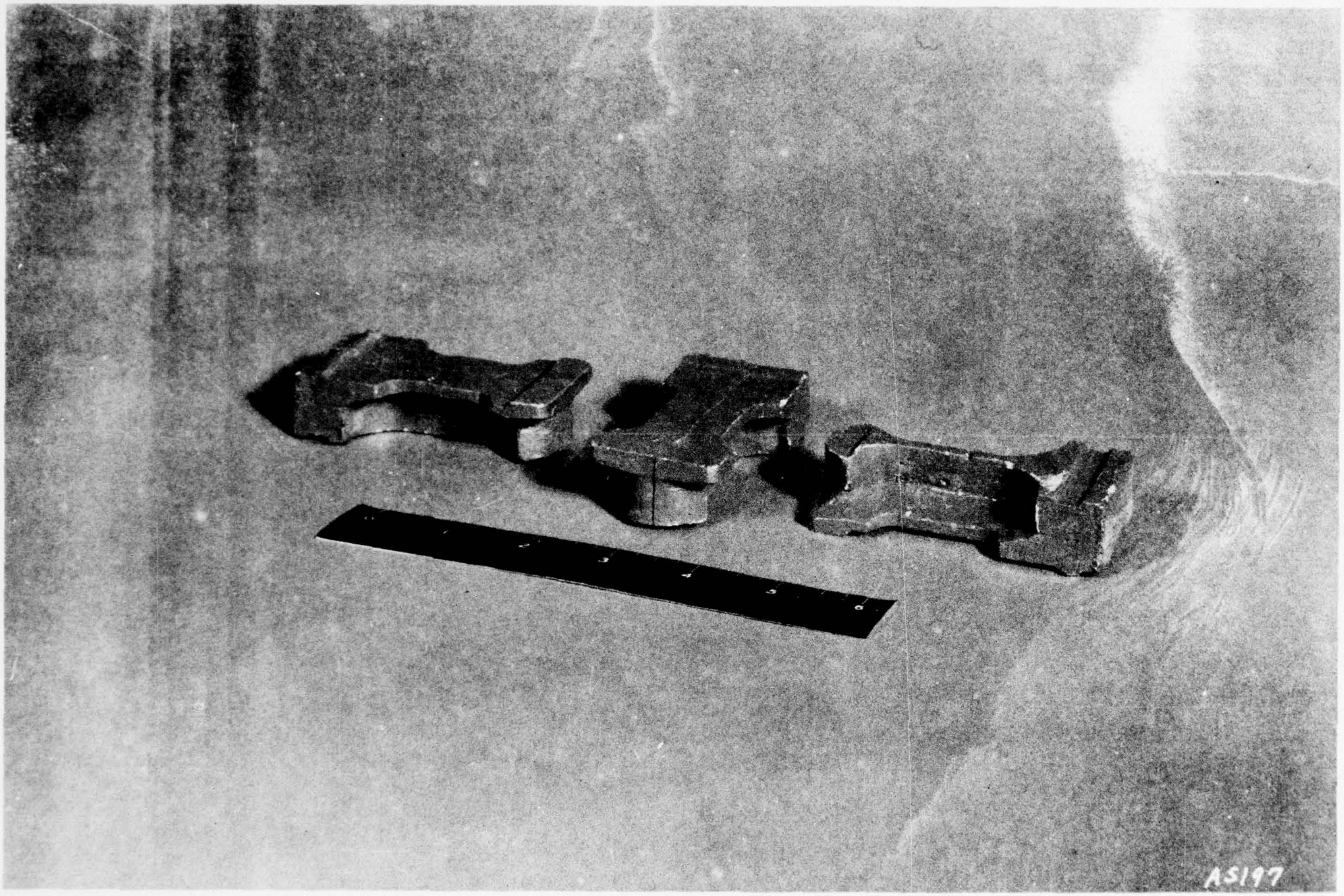


Photo 1. Igloo wave absorber unit

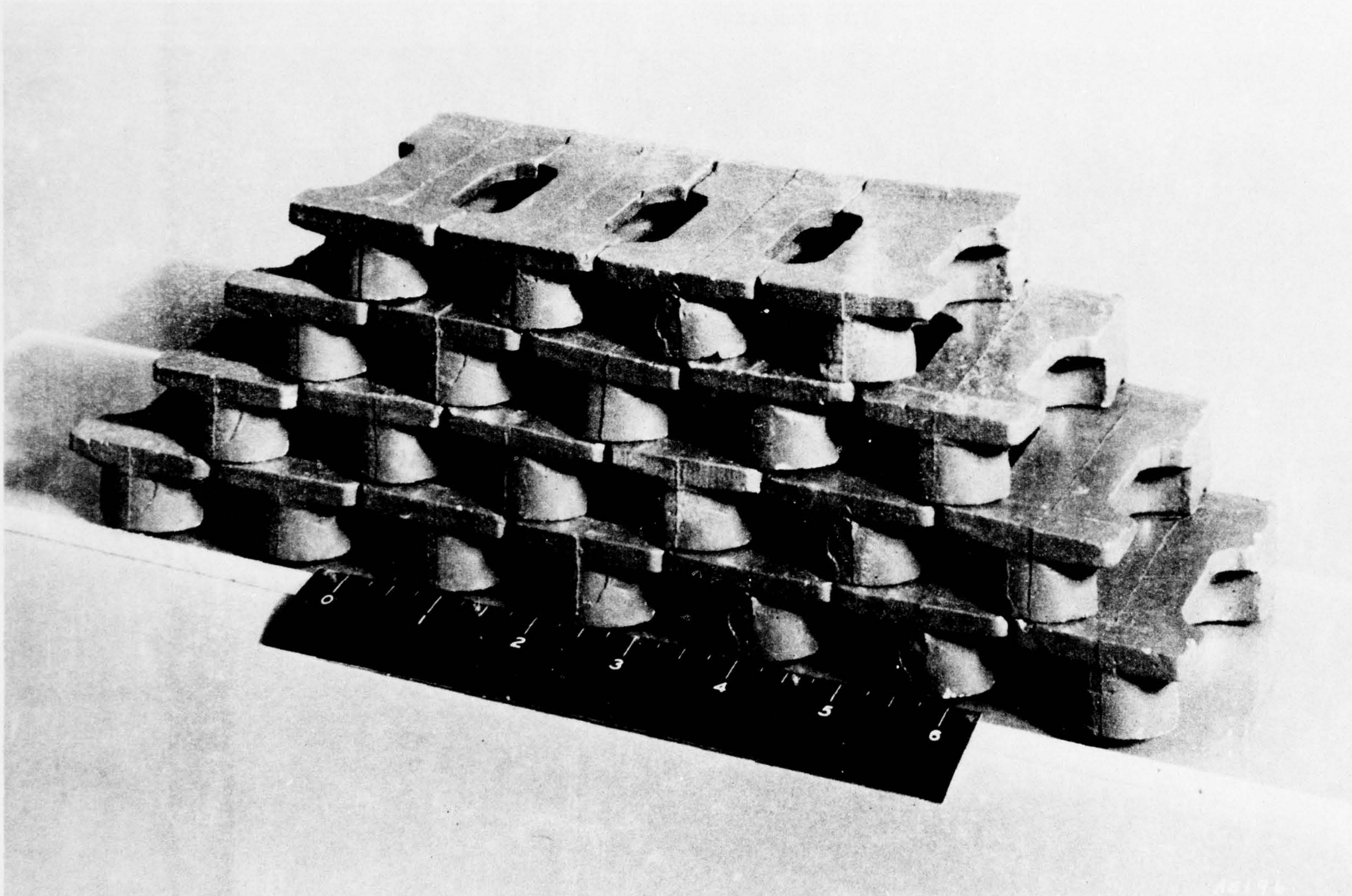
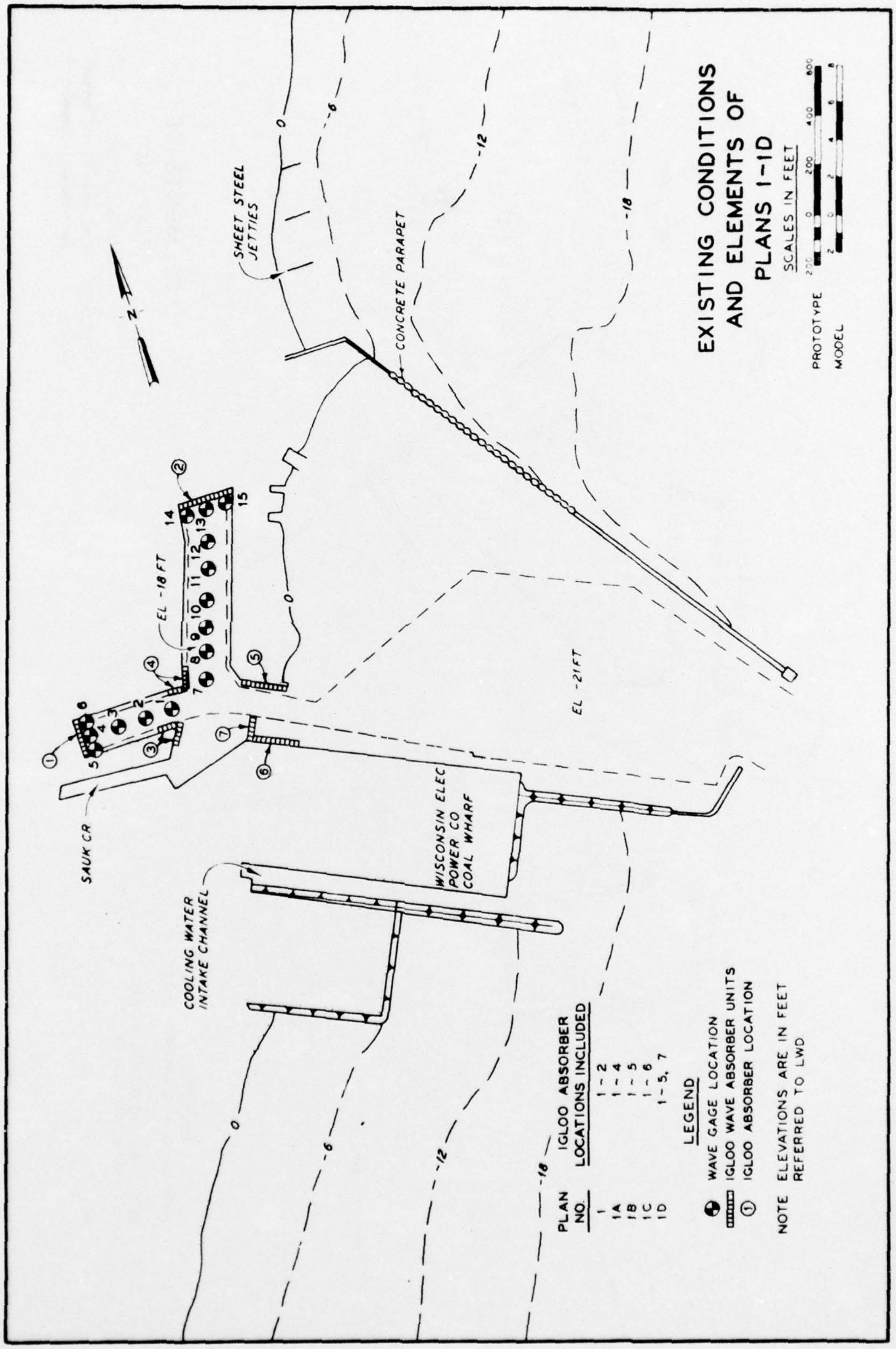


Photo 2. Stacked Igloo wave absorber units


EXISTING CONDITIONS AND ELEMENTS OF PLANS 1-1D
SCALES IN FEET
PROTOTYPE 200 0 200 400 600
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1B 1-5
1C 1-6
1D 1-5, 7
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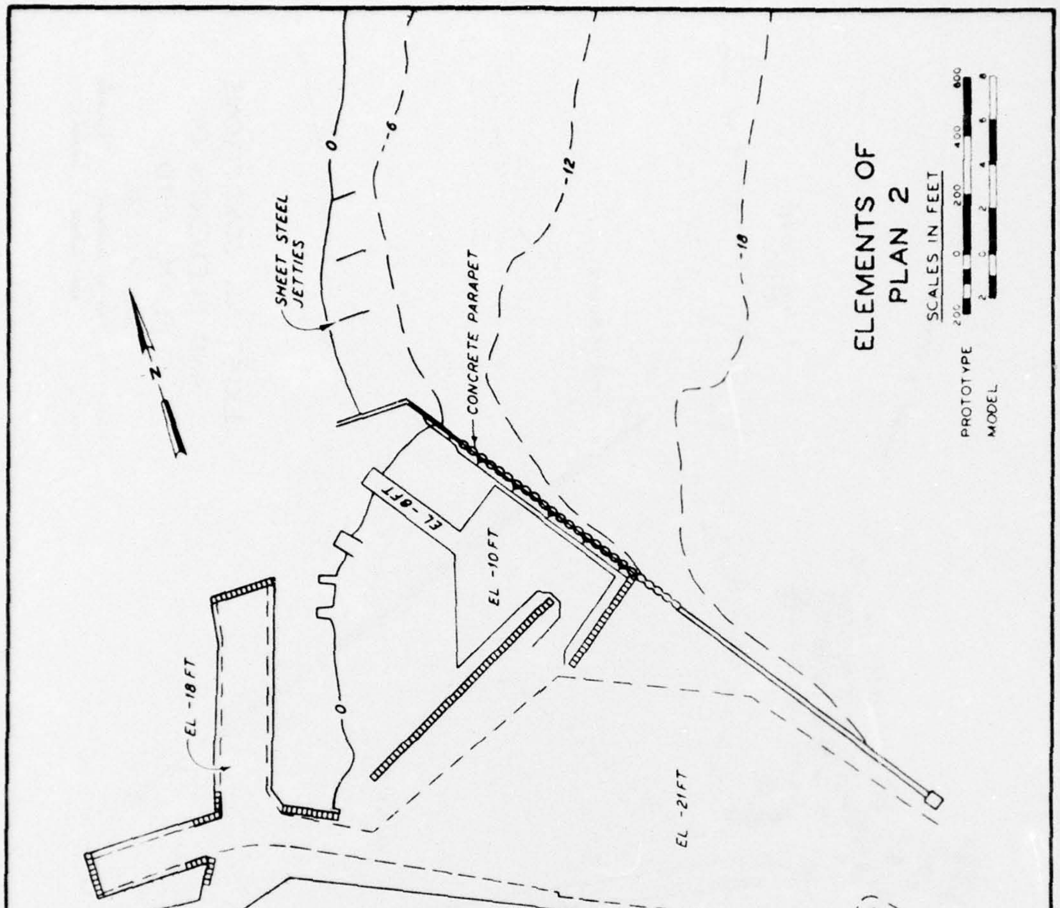
WAVE GAGE LOCATION
IGLOO WAVE ABSORBER UNITS
IGLOO ABSORBER LOCATION
NOTE ELEVATIONS ARE IN FEET REFERRED TO LWD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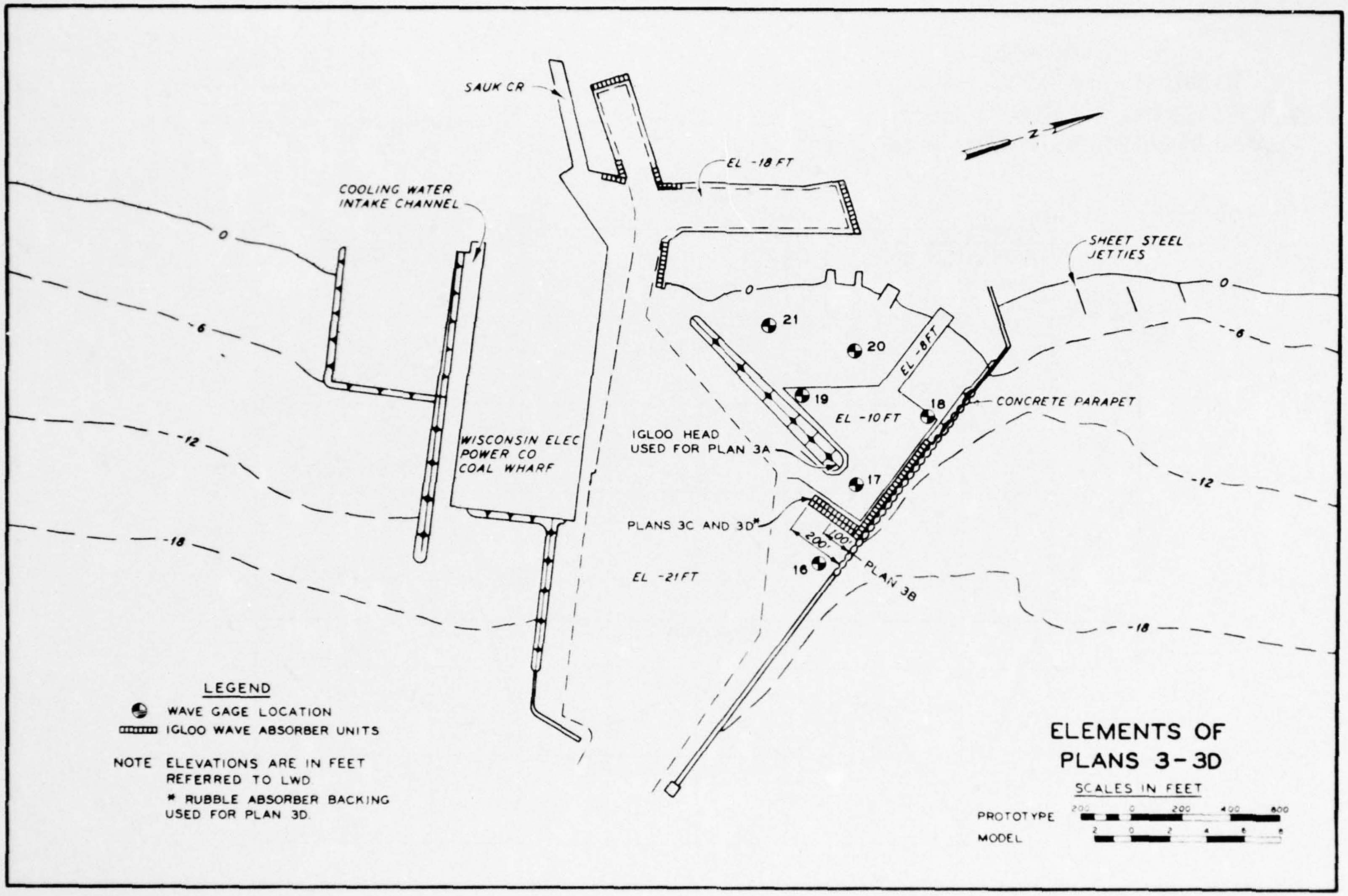
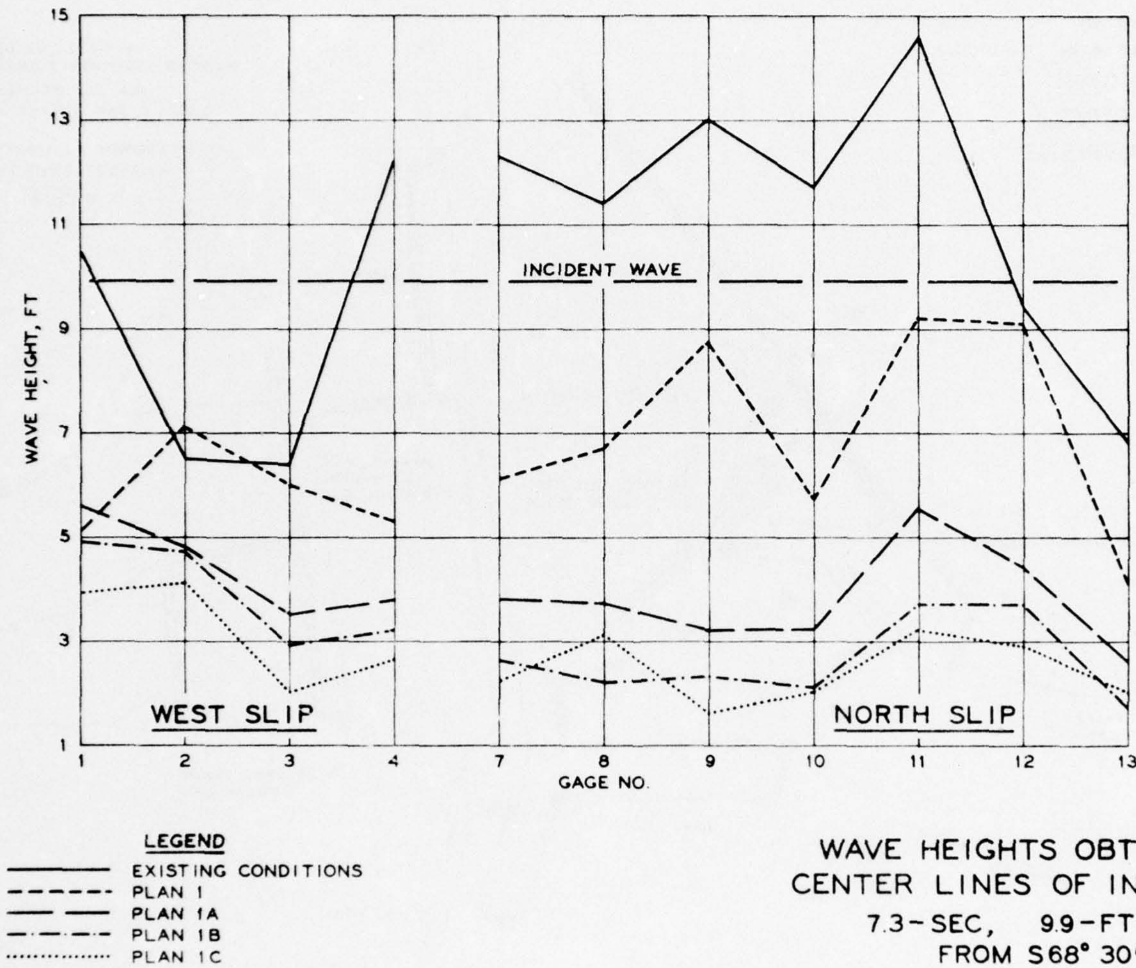
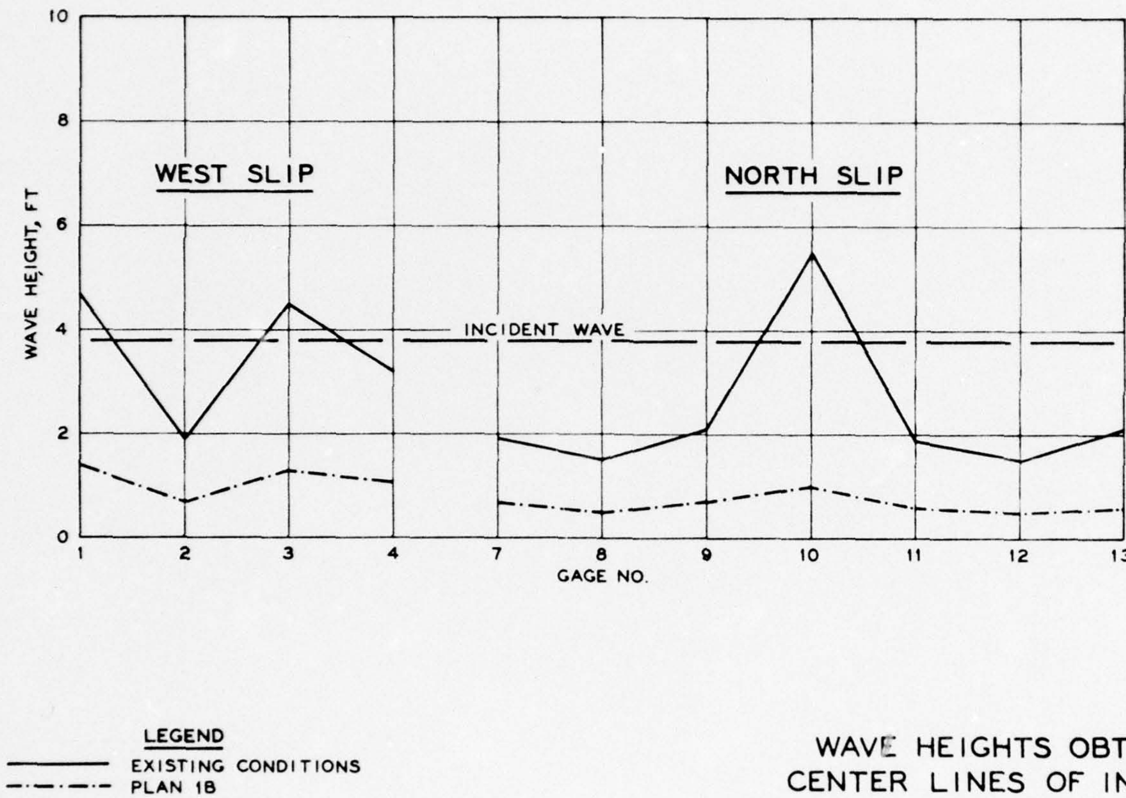
-12
-18


SAUK CR
EL -18 FT
COOLING WATER
INTAKE CHANNEL
SHEET STEEL
JETTIES
0
-6
-12
-18
21
20
EL -8 FT
19
18
CONCRETE PARAPET
EL -10 FT
WISCONSIN ELEC
POWER CO
COAL WHARF
IGLOO HEAD
USED FOR PLAN 3A
17
PLANS 3C AND 3D*
100'
200'
16
PLAN 3B
EL -21 FT
LEGEND
WAVE GAGE LOCATION
IGLOO WAVE ABSORBER UNITS
NOTE ELEVATIONS ARE IN FEET
REFERRED TO LWD
* RUBBLE ABSORBER BACKING
USED FOR PLAN 3D.
ELEMENTS OF
PLANS 3-3D
SCALES IN FEET
PROTOTYPE 200 0 200 400 600
MODEL 2 0 2 4 6 8



WAVE HEIGHTS OBTAINED AT CENTER LINES OF INNER SLIPS

7.3-SEC, 9.9-FT WAVES FROM S68° 30'E



WAVE HEIGHTS OBTAINED AT
CENTER LINES OF INNER SLIPS

5.5-SEC, 3.8-FT WAVES
FROM S68° 30'E

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Bottin, Robert R
Igloo wave absorber tests for Port Washington Harbor, Wisconsin; hydraulic model investigation, by Robert R. Bottin, Jr. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1976.
1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Miscellaneous paper H-76-22)
Prepared for Nippon Tetrapod Co., Ltd., Shimbashi, Japan.
Includes bibliography.

1. Breakwaters. 2. Harbor facilities. 3. Hydraulic models. 4. Igloo wave absorbers. 5. Port Washington, Wis. -- Harbor. 6. Standing waves. 7. Storm waves. 8. Water wave absorbers. I. Nippon Tetrapod Co., Ltd. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper H-76-22)
TA7.W34m no.H-76-22